

List of Claims

1. (original) A method injecting fuel, comprising the steps of:
injecting fuel in a first spray pattern at least in part by energizing one of a plurality of electrical actuators, relieving fuel pressure in a first needle control chamber and moving a first needle valve member in a direction with respect to a second needle valve member; and

injecting fuel in a second spray pattern at least in part by energizing a different one of said plurality of electrical actuators, relieving fuel pressure in a second needle control chamber and moving a second needle valve member in said direction within and with respect to said first needle valve member.

2. (original) The method of claim 1 wherein said direction is inward into the injector.

3. (original) The method of claim 1 wherein one of said first injecting step and said second injecting step is performed when an engine piston is closer to a bottom dead center position than a top dead center position; and

an other of said first injecting step and said second injecting step is performed when said engine piston is closer to a top dead center position than a bottom dead center position.

4. (original) The method of claim 1 wherein said injecting steps are performed in the same engine cycle.

5. (original) The method of claim 1 wherein said first spray pattern corresponds to a homogeneous charge spray pattern with a small average angle relative to a centerline; and

said second spray pattern corresponds to a conventional spray pattern with a large average angle relative to said centerline.

6. (original) The method of claim 1 wherein said first injecting step includes moving a first needle control valve member from contact with a first seat to contact with a second seat; and

said second injecting step includes a moving a second needle control valve member from contact with a first seat to contact with a second seat.

7. (original) The method of claim 1 wherein said first injecting step includes a step of closing a fluid connection between a nozzle supply passage and said first needle control chamber; and

said second injecting step includes a step of closing a fluid connection between said nozzle supply passage and said second needle control chamber.

8. (currently amended) A fuel injector comprising:

an injector body defining a first nozzle outlet set and a second nozzle outlet set that correspond to a first spray pattern and a second spray pattern, respectively;

a first needle valve member at least partially positioned in said injector body and including a first opening hydraulic surface and a first closing hydraulic surface;

a second needle valve member at least partially positioned in said injector body and including a second opening hydraulic surface and a second closing hydraulic surface;

a first electrical actuator operably coupled to said first needle valve member via a first needle control chamber, and said first closing hydraulic surface being exposed to fluid pressure in said first needle control chamber;

a second electrical actuator operably coupled to said second needle valve member via a second needle control chamber, and said second closing hydraulic surface being exposed to fluid pressure in said second needle control chamber; and

one of said first needle valve member and said second needle valve member being at least partially positioned in an other of said first needle valve member and said second needle valve member.

9. (original) The fuel injector of claim 8 wherein said first electrical actuator is operably coupled to said first needle valve member via a first three way needle control valve; and

said second electrical actuator is operably coupled to said second needle valve member via a second three way needle control valve.

10. (previously presented) The fuel injector of claim 9 wherein said first three way needle control valve closes a fluid connection between the first needle control chamber and a nozzle supply passage when in a first position; and

said second three way needle control valve closes a fluid connection between the second needle control chamber and said nozzle supply passage when in a first position.

11. (original) The fuel injector of claim 8 wherein said first spray pattern is a homogeneous charge spray pattern;

said second spray pattern is a conventional spray pattern; and

said first nozzle outlet set surrounds said second nozzle outlet set about a centerline.

12. (original) The fuel injector of claim 8 wherein one of said first nozzle outlet set and said second nozzle outlet set has a small average angle with respect to a centerline; and

an other of said first nozzle outlet set and said second nozzle outlet set has a large average angle with respect to said centerline.

13. (original) The fuel injector of claim 8 wherein said direction is inward into said injector body.

14. (original) The fuel injector of claim 8 wherein said first needle valve member is moveable in a direction with respect to said second needle valve member to an open position; and

said second needle valve member is moveable in said direction with respect to said first needle valve member to an open position.

15. (currently amended) A fuel injection system comprising:

a common fuel rail;

at least one fuel injector fluidly connected to said common fuel rail, and including an injector body defining a first nozzle outlet set and a second nozzle outlet set that correspond to a first spray pattern and a second spray pattern, respectively, and each fuel injector including a first needle valve member with a first opening hydraulic surface and a first closing hydraulic surface, and a second needle valve member with a second opening hydraulic surface and a second closing hydraulic surface;

a first electrical actuator operably coupled to open and close said first nozzle outlet set via the first closing hydraulic surface of the first needle valve member being exposed to fluid pressure in and a first needle control chamber;

a second electrical actuator operably coupled to open and close said second nozzle outlet set via the second closing hydraulic surface of the second needle valve member being exposed to fluid pressure in and a second needle control chamber; and

one of said first needle valve member and said second needle valve member being at least partially positioned in an other of said first needle valve member and said second needle valve member.

16. (original) The fuel injection system of claim 8 wherein said first electrical actuator is operably coupled to said first needle valve member via a first three way needle control valve; and

said second electrical actuator is operably coupled to said second needle valve member via a second three way needle control valve.

17. (previously presented) The fuel injection system of claim 16 wherein said first three way needle control valve closes a fluid connection between the first needle control chamber and a nozzle supply passage when in a first position; and

said second three way needle control valve closes a fluid connection between the second needle control chamber and said nozzle supply passage when in a first position.

18. (original) The fuel injection system of claim 15 wherein one of said first nozzle outlet set and said second nozzle outlet set has a small average angle with respect to a centerline; and

an other of said first nozzle outlet set and said second nozzle outlet set has a large average angle with respect to said centerline.

19. (original) The fuel injection system of claim 15 wherein said direction is inward into said injector body.

20. (original) The fuel injection system of claim 15 wherein said first needle valve member is moveable in a direction with respect to said second needle valve member to an open position; and

said second needle valve member is moveable in said direction with respect to said first needle valve member to an open position.